

AD-A117 908

NAVAL RESEARCH LAB WASHINGTON DC

F/G 4/1

EFFECT OF AN ELECTRON BEAM ON THE CURRENT CONVECTIVE INSTABILITY--ETC(U)

JUL 82 P K CHATURVEDI, S L OSSAKOW

UNCLASSIFIED

NRL-MR-4858

NL

1 10 1
100

END
DATE
FILMED
9 '82
DTIC

AD A117948

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NRL Memorandum Report 4858	2. GOVT ACCESSION NO. AD-A117 908	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EFFECT OF AN ELECTRON BEAM ON THE CURRENT CONVECTIVE INSTABILITY		5. TYPE OF REPORT & PERIOD COVERED Interim report on a continuing NRL problem.
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P.K. Chaturvedi* and S.L. Ossakow		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Research Laboratory Washington, DC 20375		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61153N; 62715H; RR033-02-44; 47-0883-02; 47-0889-0-2
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Nuclear Agency Office of Naval Research Washington, DC 20305 Arlington, VA 22217		12. REPORT DATE July 23, 1982
		13. NUMBER OF PAGES 17
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES *Present address: Science Applications, Inc., McLean, VA 22102 This research was sponsored partially by the Defense Nuclear Agency under Subtask S99QAXHC, work unit 00032 and work unit title "Plasma Structure Evolution," and partially by the Office of Naval Research.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Current convective instability Effects of electron beam Diffuse aurora Linear stability analysis		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) We consider the possible effects of an electron beam on the current convective instability in a weakly ionized plasma, with application to the diffuse auroral-like situation. A linear instability analysis including these effects is presented.		

DD FORM 1473
1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

EFFECT OF AN ELECTRON BEAM ON THE CURRENT CONVECTIVE INSTABILITY

The current convective instability (CCI) has recently been cited as playing a role in the generation of scintillation causing large scale size plasma irregularities in the diffuse aurora [Ossakow and Chaturvedi, 1979; Chaturvedi and Ossakow, 1979; Keskinen et al., 1980; Vickrey et al., 1980; Chaturvedi and Ossakow, 1981; Keskinen and Ossakow, 1982; Rino and Vickrey, 1982]. This instability is caused by a field-aligned current in the presence of a transverse plasma density gradient in a collisional plasma [Kadomtsev and Nedospasov, 1960]. In the diffuse auroral situation, it is generally recognized that a significant part of the observed field-aligned current is carried by the cold ionospheric electron component, drifting relative to ions. It is this electron drift that causes a variety of current driven plasma instabilities in the system, such as the current convective instability. However, a precipitating flux of soft energetic electrons are also present alongside the cold drifting electrons in the medium. In our previous work (Ossakow and Chaturvedi, 1979) only the cold electron drift component was considered. In this note, we have examined the effects of an electron beam (in addition to the cold drifting electron component) along the magnetic field on the current convective instability. It is found that, though the presence of an electron beam modifies the current convective instability growth rate, in the diffuse auroral application, such effects are practically negligible.

We follow the approach outlined in Ossakow and Chaturvedi [1979] in the linear stability analysis. The coordinate system has the magnetic field aligned with the z-axis, as does the cold electron drift v_0 . A density gradient along the y-axis and an electron beam of density n_b and velocity v_{b2} are also present. In the following the beam and the cold plasma quantities will be denoted by subscripts b and c respectively. Further, the temperature effects for the cold plasma component are neglected. Our basic equations are

$$\frac{\partial n_\alpha}{\partial t} + \nabla \cdot (n_\alpha \mathbf{v}_\alpha) = 0 \quad (1)$$

$$\frac{v_1}{\Omega_1} = \frac{c}{B_0} \frac{E_1}{\Omega_1} \times \hat{z} + \frac{v_{1n}}{\Omega_1} \frac{c}{B_0} \frac{E_1}{\Omega_1} + \frac{e}{m_1 v_{1n}} \frac{E_z}{\Omega_1} \quad (2)$$

$$\underline{v}_{ec} = \frac{c}{B_0} \underline{E}_\perp \times \hat{z} - \frac{e}{m_e v_{ecn}} \underline{E}_z + v_0 \hat{z} \quad (3)$$

$$\underline{v}_{eb} = \frac{c}{B_0} \underline{E}_\perp \times \hat{z} + \frac{c T_{eb}}{e B_0} \nabla_\perp n_b \times \hat{z} - \frac{T_{eb}}{m_e v_{ebn} n_{eb}} \frac{\partial n_b}{\partial z} \hat{z} - \frac{e}{m_e v_{ebn}} \underline{E}_z + v_b \hat{z} \quad (4)$$

$$\nabla \cdot \underline{J} = 0, \underline{J} = \sum n_\alpha e_\alpha \underline{v}_\alpha \quad (5)$$

Most of the symbols have their standard meaning, α denotes the particle species ($i \equiv$ ions, $e \equiv$ electrons), n is the density, $v_{\alpha n}$ denotes the collision frequency of the species α with neutrals, T_{eb} is the beam electron temperature in energy units and subscripts \perp and z represent perpendicular and parallel to the magnetic field respectively, etc. In equations (2)-(4), inertial effects were neglected, Pedersen mobility effects for electrons were also neglected in comparison to the ion Pedersen drift. In the stability analysis, quantities are split into equilibrium and perturbed components, $f = f_0 + \hat{f}$ with the perturbed quantities varying as $\propto \exp(i\mathbf{k} \cdot \mathbf{r} - i\omega t)$. An assumption of quasi-neutrality is made, i.e.,

$$\hat{n}_i = \hat{n}_{eb} + \hat{n}_{ec}$$

Following Ossakow and Chaturvedi [1979], one writes for the perturbed electron and ion densities,

$$\hat{n}_{ec} = n_{oc} \hat{\phi} \frac{(k_z^2 \frac{e}{m_e v_{ecn}} + i \frac{c}{B_0} \underline{k}_\perp \times \hat{z} \cdot \nabla_\perp \ln n_{oc})}{(-i\omega + i k_z v_0)} \quad (6)$$

$$\hat{n}_{eb} = n_b \hat{\phi} \frac{(k_z^2 \frac{e}{m_e v_{ebn}} + i \frac{c}{B_0} \underline{k}_\perp \times \hat{z} \cdot \nabla_\perp \ln n_b)}{(-i\omega + i k_z v_b + \frac{T_{eb} k_z^2}{m_e v_{ebn}})} \quad (7)$$

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

and

$$\tilde{n}_1 = n_{oc} \tilde{\phi} \frac{[i \frac{c}{B_o} \underline{k}_1 \underline{xz} \cdot \nabla_1 \ln n_{oc} - \frac{ek_z^2}{m_i v_{in}} - \frac{v_{in} c}{\Omega_i B_o} k_1^2]}{[-i\omega + ik_z v_{oiz}]} \quad (8)$$

In the above, we have made the electrostatic assumption for the perturbed electric fields, $\underline{\tilde{E}} = -\nabla \tilde{\phi}$. From the set (6)-(8), one readily obtains

$$\begin{aligned} & \omega \left[\frac{k_z^2}{k_1^2} \beta + \frac{v_{in} v_{ecn}}{\Omega_e \Omega_i} \right] - k_z v_o \left[-i \frac{v_{ecn}}{\Omega_e} \frac{\underline{k}_1 \underline{xz} \cdot \nabla_1 \ln n_{oc}}{k_1^2} + \frac{m_e}{m_i} \frac{v_{ecn}}{v_{in}} \frac{k_z^2}{k_1^2} + \frac{v_{ecn} v_{in}}{\Omega_e \Omega_i} \right] \\ &= - \frac{n_b}{n_{oc}} \omega \frac{(\omega - k_z v_o)}{(\omega - k_z v_b + i \frac{T_{eb} k_z^2}{m_e v_{ebn}})} \frac{v_{ecn}}{v_{ebn}} \left[\frac{k_z^2}{k_1^2} + i \frac{v_{ebn}}{\Omega_e} \frac{\underline{k}_1 \underline{xz} \cdot \nabla_1 \ln n_b}{k_1^2} \right] \end{aligned} \quad (9)$$

where $\beta \equiv [1 + (v_{ecn} m_e / v_{in} m_i)]$. The right hand side of equation (9) contains the effects of an electron beam on the mode driven unstable by the current convective instability, which is described by the left hand side of eq. (9) (i.e., setting $n_b/n_{oc} = 0$ one regains the dispersion relation obtained by Ossakow and Chaturvedi, 1979).

As an illustrative example and a special case of interest, we assume the electron beam to be cold ($T_{eb} \approx 0$) and uniform ($\nabla_1 \ln n_b \approx 0$). One then obtains, from eq. (9),

$$\omega = k_z v_o \frac{[-i \frac{v_{ecn}}{\Omega_e} \frac{\underline{k}_1 \underline{xz} \cdot \nabla_1 \ln n_{oc}}{k_1^2} + \frac{m_e}{m_i} \frac{v_{ecn}}{v_{in}} \frac{k_z^2}{k_1^2} + \frac{v_{ecn} v_{in}}{\Omega_e \Omega_i}]}{[\frac{k_z^2}{k_1^2} (1 + \frac{n_b}{n_{oc}} \frac{v_o}{v_b} \frac{v_{ecn}}{v_{ebn}}) + \frac{v_{in} v_{ecn}}{\Omega_e \Omega_i}]} \quad (10)$$

so that (with $\omega \equiv \omega_R + i\gamma$)

$$\gamma \approx -k_z v_o \frac{v_{ecn}}{\Omega_e} \frac{k_{\perp} x z \cdot \nabla_{\perp} \ln n_{oc}}{k_{\perp}^2} \frac{1}{\left[\frac{k_z^2}{k_{\perp}^2} \left(1 + \frac{n_b}{n_{oc}} \frac{v_o}{v_b} \frac{v_{ecn}}{v_{bn}} \right) + \frac{v_{in} v_{ecn}}{\Omega_i \Omega_e} \right]} \quad (10a)$$

In deriving equation (10), we further assumed that $m_e v_{ecn}/m_i v_{in} \ll 1$, $\omega \ll k_z v_o, k_z v_b$. The latter assumption is reasonable, since we are interested in the effects of the beam on the mode which grows due to an absolute instability (without the above assumptions, (9) has two roots, one given by (10) and the other yielding $\omega \approx k_z v_b$). In the absence of the beam ($n_b \approx 0$), this relation leads to the one obtained in Ossakow and Chaturvedi [1979]. For a beam such that $n_b/n_{oc} \approx 10^{-2}$ and $v_b \approx 3.5 \times 10^8 \text{ cm s}^{-1}$ (corresponding to electron fluxes of energy $\sim 100 \text{ eV}$), one finds that the beam induced contribution in the denominator of eq. (10) is down by $\sim 0(10^{-5})$ compared to the leading term (where we have used $v_o \sim 1 \text{ km s}^{-1}$). However, one notes that the beam contribution would decrease (enhance) the growth rate somewhat if the electron beam velocity and the electron drift were parallel (anti-parallel).

Allowing for a non-uniform beam one gets

$$\omega \approx k_z v_o \frac{\left[-i \frac{v_{ecn}}{\Omega_e} \frac{k_{\perp} x z \cdot \nabla_{\perp} \ln n_{oc}}{k_{\perp}^2} + \frac{m_e}{m_i} \frac{v_{ecn}}{v_{in}} \frac{k_z^2}{k_{\perp}^2} + \frac{v_{ecn} v_{in}}{\Omega_e \Omega_i} \right]}{\left[\frac{k_z^2}{k_{\perp}^2} \sigma + \frac{v_{in} v_{ecn}}{\Omega_e \Omega_i} + 1 \left(\frac{n_b}{n_{oc}} \frac{v_o}{v_b} \frac{v_{ecn}}{v_{bn}} \right) \frac{v_{bn}}{\Omega_e} \cdot \frac{k_{\perp} x z \cdot \nabla_{\perp} \ln n_b}{k_{\perp}^2} \right]} \quad (11)$$

where $\sigma \equiv 1 + (n_b v_o v_{ecn}/n_{oc} v_b v_{bn})$.

One gets for the growth rate of the current convective instability

($\omega \equiv \omega_R + i\gamma$),

$$\gamma \approx k_z v_o \frac{\left[-\frac{v_{ecn}}{\Omega_e} \frac{k_{\perp} x z \cdot \nabla_{\perp} \ln n_{oc}}{k_{\perp}^2} \left(\frac{k_z^2}{k_{\perp}^2} + \frac{v_{in} v_{ecn}}{\Omega_e \Omega_i} \right) - \delta \left(\frac{m_e}{m_i} \frac{k_z^2}{k_{\perp}^2} \frac{v_{ecn}}{v_{in}} + \frac{v_{ecn} v_{in}}{\Omega_e \Omega_i} \right) \right]}{\left[\left(\sigma \frac{k_z^2}{k_{\perp}^2} + \frac{v_{in} v_{ecn}}{\Omega_e \Omega_i} \right)^2 + \delta^2 \right]^2} \quad (11a)$$

where $\delta \{ \equiv n_b v_o v_{ecn} \frac{\hat{k}_1 x z \cdot \nabla_1 \ln n_b}{(n_{oc} v_b \Omega_e k_1^2)} \}$ denotes the effects of beam non-uniformity. We now see that the beam effects are more complex than before on the growth rate of the CCI, and their contributions to reduce or increase the growth rate would depend on, in addition to the relative sense between beam velocity and the drift direction, the direction of the beam density gradient. However, for diffuse aurora situations, a beam with parameters, $n_b/n_{oc} \sim 10^{-2}$, and $v_b \sim 3 \times 10^8 \text{ cm s}^{-1}$, these contributions are down by a factor of $\sim 0(10^{-5})$ for equal beam density and cold background density gradients (where we have used $v_o \sim 1 \text{ km s}^{-1}$). Therefore, beam effects appear to be much too small to have any practical implications on the growth rate of the CCI.

In conclusion, we find that the soft precipitating fluxes of electrons ($\sim 100 \text{ eV}$) may have little effect on the large scale size ($\sim 1 \text{ km}$) slow processes like the current convective instability induced structures for the diffuse auroral situation. However, in calculating growth rates or stability thresholds from say (10a) with even $n_b = 0$ one must notice that it is v_o (i.e., the cold current velocity) that enters the growth rate. Since magnetometers infer total parallel (to B_o) current from their measurements (T. Potemra, private communication, 1981), one must be able to separate (or assess) the warm parallel current contribution from (to) the total current. Letting the total parallel current be proportional to v_o ($J_z = nev_o$) can lead to an underestimate of v_o when \underline{v}_o and \underline{v}_b are anti-parallel.

ACKNOWLEDGMENTS

This research was supported by the Defense Nuclear Agency and the Office of Naval Research. We wish to thank Dr. E. Fremouw of Physical Dynamics, Inc. for raising the question of (at a dinner during the 1981 Scotland IAGA Meeting) what happens to the current convective instability when a warm electron beam is present and so precipitating this study.

REFERENCES

- Chaturvedi, P.K. and S.L. Ossakow, Nonlinear stabilization of the current convective instability in the diffuse aurora, Geophys. Res. Lett., 6, 957, 1979.
- Chaturvedi, P.K. and S.L. Ossakow, The current convective instability as applied to the auroral ionosphere, J. Geophys. Res., 86, 4811, 1981.
- Kadomtsev, B.B. and A.V. Nedospasov, Instability of the positive column in a magnetic field and the "anomalous diffusion effect", J. Nucl. Energy, Part C, 1, 230, 1960.
- Keskinen, M.J., S.L. Ossakow, and B.E. McDonald, Nonlinear evolution of diffuse auroral F region ionospheric irregularities, Geophys. Res. Lett., 7, 573, 1980.
- Keskinen, M.J. and S.L. Ossakow, Nonlinear evolution of plasma enhancements in the auroral ionosphere I: long wavelength irregularities, J. Geophys. Res., 87, 144, 1982.
- Ossakow, S.L. and P.K. Chaturvedi, Current convective instability in the diffuse aurora, Geophys. Res. Lett., 6, 332, 1979.
- Rino, C.L. and J.F. Vickrey, Recent results in auroral zone scintillation studies, submitted to J. Atm. Terr. Phys., 1982.
- Vickrey, J.F., C.L. Rino, and T.A. Potemra, Chatanika/Triad observations of unstable ionization enhancements in the auroral F region, Geophys. Res. Lett., 7, 789, 1980.

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

ASSISTANT SECRETARY OF DEFENSE
COMM, CMD, CONT 7 INTELL
WASHINGTON, D.C. 20301
O1CY ATTN J. BABCOCK
O1CY ATTN M. EPSTEIN

DIRECTOR
COMMAND CONTROL TECHNICAL CENTER
PENTAGON RM BE 685
WASHINGTON, D.C. 20301
O1CY ATTN C-650
O1CY ATTN C-312 R. MASON

DIRECTOR
DEFENSE ADVANCED RSCH PROJ AGENCY
ARCHITECT BUILDING
1400 WILSON BLVD.
ARLINGTON, VA. 22209
O1CY ATTN NUCLEAR MONITORING RESEARCH
O1CY ATTN STRATEGIC TECH OFFICE

DEFENSE COMMUNICATION ENGINEER CENTER
1860 WIEHLE AVENUE
RESTON, VA. 22090
O1CY ATTN CODE R820
O1CY ATTN CODE R410 JAMES W. MCLEAN
O1CY ATTN CODE R720 J. WORTHINGTON

DIRECTOR
DEFENSE COMMUNICATIONS AGENCY
WASHINGTON, D.C. 20305
(ADR CNWDI: ATTN CODE 240 FOR)
O1CY ATTN CODE 101B

DEFENSE TECHNICAL INFORMATION CENTER
CAMERON STATION
ALEXANDRIA, VA. 22314
O2CY

DIRECTOR
DEFENSE NUCLEAR AGENCY
WASHINGTON, D.C. 20305
O1CY ATTN STVL
O4CY ATTN TITL
O1CY ATTN DDST
O3CY ATTN RAAE

COMMANDER
FIELD COMMAND
DEFENSE NUCLEAR AGENCY
KIRTLAND, AFB, NM 87115
O1CY ATTN FCPR

DIRECTOR
INTERSERVICE NUCLEAR WEAPONS SCHOOL
KIRTLAND AFB, NM 87115
O1CY ATTN DOCUMENT CONTROL

JOINT CHIEFS OF STAFF
WASHINGTON, D.C. 20301
O1CY ATTN J-3 WWMCCS EVALUATION OFFICE

DIRECTOR
JOINT STRAT TGT PLANNING STAFF
OFFUTT AFB
OMAHA, NB 68113
O1CY ATTN JLTW-2
O1CY ATTN JPST G. GOETZ

CHIEF
LIVERMORE DIVISION FLD COMMAND DNA
DEPARTMENT OF DEFENSE
LAWRENCE LIVERMORE LABORATORY
P.O. BOX 808
LIVERMORE, CA 94550
O1CY ATTN FCPRL

COMMANDANT
NATO SCHOOL (SHAPE)
APO NEW YORK 09172
O1CY ATTN U.S. DOCUMENTS OFFICER

UNDER SECY OF DEF FOR RSCH & ENGRG
DEPARTMENT OF DEFENSE
WASHINGTON, D.C. 20301
O1CY ATTN STRATEGIC & SPACE SYSTEMS (OS)

WWMCCS SYSTEM ENGINEERING ORG
WASHINGTON, D.C. 20305
O1CY ATTN R. CRAWFORD

COMMANDER/DIRECTOR
ATMOSPHERIC SCIENCES LABORATORY
U.S. ARMY ELECTRONICS COMMAND
WHITE SANDS MISSILE RANGE, NM 88002
O1CY ATTN DELAS-EO F. NILES

DIRECTOR
BMD ADVANCED TECH CTR
HUNTSVILLE OFFICE
P.O. BOX 1500
HUNTSVILLE, AL 35807
O1CY ATTN ATC-T MELVIN T. CAPPS
O1CY ATTN ATC-O W. DAVIES
O1CY ATTN ATC-R DON RUSS

PROGRAM MANAGER
BMD PROGRAM OFFICE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333
O1CY ATTN DACS-BMT J. SHEA

CHIEF C-E- SERVICES DIVISION
U.S. ARMY COMMUNICATIONS CMD
PENTAGON RM 1B269
WASHINGTON, D.C. 20310
O1CY ATTN C- E-SERVICES DIVISION

COMMANDER
FRADCOM TECHNICAL SUPPORT ACTIVITY
DEPARTMENT OF THE ARMY
FORT MONMOUTH, N.J. 07703
O1CY ATTN DRSEL-NL-RD H. BENNET
O1CY ATTN DRSEL-PL-ENV H. BOMKE
O1CY ATTN J.E. QUIGLEY

COMMANDER
HARRY DIAMOND LABORATORIES
DEPARTMENT OF THE ARMY
2800 POWDER MILL ROAD
ADELPHI, MD 20783
(CNWDI-INNER ENVELOPE: ATTN: DELHD-RBH)
O1CY ATTN DELHD-TI M. WEINER
O1CY ATTN DELHD-RB R. WILLIAMS
O1CY ATTN DELHD-NP F. WIMENITZ
O1CY ATTN DELHD-MP C. MOAZED

COMMANDER
U.S. ARMY COMM-ELEC ENGRG INSTAL AGY
FT. HUACHUCA, AZ 85613
O1CY ATTN CCC-EMEO GEORGE LANE

COMMANDER
U.S. ARMY FOREIGN SCIENCE & TECH CTR
220 7TH STREET, NE
CHARLOTTESVILLE, VA 22901
O1CY ATTN DRXST-SD
O1CY ATTN R. JONES

COMMANDER
U.S. ARMY MATERIAL DEV & READINESS CMD
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333

O1CY ATTN DRCLDC J.A. BENDER
COMMANDER
U.S. ARMY NUCLEAR AND CHEMICAL AGENCY
7500 BACKLICK ROAD
BLDG 2073
SPRINGFIELD, VA 22150
O1CY ATTN LIBRARY

DIRECTOR
U.S. ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MD 21005
O1CY ATTN TECH LIBRARY EDWARD BAICY

COMMANDER
U.S. ARMY SATCOM AGENCY
FT. MONMOUTH, NJ 07703
O1CY ATTN DOCUMENT CONTROL

COMMANDER
U.S. ARMY MISSILE INTELLIGENCE AGENCY
REDSTONE ARSENAL, AL 35809
O1CY ATTN JIM GAMBLE

DIRECTOR
U.S. ARMY TRADOC SYSTEMS ANALYSIS ACTIVITY
WHITE SANDS MISSILE RANGE, NM 88002
O1CY ATTN ATAA-SA
O1CY ATTN TCC/F. PAYAN JR.
O1CY ATTN ATTA-TAC LTC J. HESSE

COMMANDER
NAVAL ELECTRONIC SYSTEMS COMMAND
WASHINGTON, D.C. 20360
O1CY ATTN NAVALEX 034 T. HUGHES
O1CY ATTN PME 117
O1CY ATTN PME 117-T
O1CY ATTN CODE 5011

COMMANDING OFFICER
NAVAL INTELLIGENCE SUPPORT CTR
4301 SUITLAND ROAD, BLDG. 5
WASHINGTON, D.C. 20390
O1CY ATTN MR. DUBBIN STIC 12
O1CY ATTN NISC-50
O1CY ATTN CODE 5404 J. GALET

COMMANDER
NAVAL OCCEAN SYSTEMS CENTER
SAN DIEGO, CA 92152
O3CY ATTN CODE 532 W. MOLER
O1CY ATTN CODE 0230 C. BAGGETT
O1CY ATTN CODE 81 R. EASTMAN

DIRECTOR
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C. 20375
01CY ATTN CODE 4700 S. L. Ossakow
26 CYS IF UNCLASS. 1 CY IF CLASS)
01CY ATTN CODE 4701 JACK D. BROWN
01CY ATTN CODE 4780 BRANCH HEAD (150
CYS IF UNCLASS, 1 CY IF CLASS)
01CY ATTN CODE 7500
01CY ATTN CODE 7550
01CY ATTN CODE 7580
01CY ATTN CODE 7551
01CY ATTN CODE 7555
01CY ATTN CODE 4730 E. MCLEAN
01CY ATTN CODE 4187
20CY ATTN CODE 2628

COMMANDER
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C. 20362
01CY ATTN CAPT R. PITKIN

COMMANDER
NAVAL SPACE SURVEILLANCE SYSTEM
DAHLGREN, VA 22448
01CY ATTN CAPT J.H. BURTON

OFFICER-IN-CHARGE
NAVAL SURFACE WEAPONS CENTER
WHITE OAK, SILVER SPRING, MD 20910
01CY ATTN CODE F31

DIRECTOR
STRATEGIC SYSTEMS PROJECT OFFICE
DEPARTMENT OF THE NAVY
WASHINGTON, D.C. 20376
01CY ATTN NSP-2141
01CY ATTN NSSP-2722 FRED WIMBERLY

COMMANDER
NAVAL SURFACE WEAPONS CENTER
DAHLGREN LABORATORY
DAHLGREN, VA 22448
01CY ATTN CODE DF-14 R. BUTLER

OFFICER OF NAVAL RESEARCH
ARLINGTON, VA 22217
01CY ATTN CODE 465
01CY ATTN CODE 461
01CY ATTN CODE 402
01CY ATTN CODE 420
01CY ATTN CODE 421

COMMANDER
AEROSPACE DEFENSE COMMAND/DC
DEPARTMENT OF THE AIR FORCE
ENT AFB, CO 80912
01CY ATTN DC MR. LONG

COMMANDER
AEROSPACE DEFENSE COMMAND/XPD
DEPARTMENT OF THE AIR FORCE
ENT AFB, CO 80912
01CY ATTN XPDQQ
01CY ATTN XP

AIR FORCE GEOPHYSICS LABORATORY
HANSCOM AFB, MA 01731
01CY ATTN OPR HAROLD GARDNER
01CY ATTN LKB KENNETH S.W. CHAMPION
01CY ATTN OPR ALVA T. STAIR
01CY ATTN PHP JULES AARONS
01CY ATTN PHD JURGEN BUCHAU
01CY ATTN PHD JOHN P. MULLEN

AF WEAPONS LABORATORY
KIRTLAND AFT, NM 87117
01CY ATTN SUL
01CY ATTN CA ARTHUR H. GUENTHER
01CY ATTN NTYCE 1LT. G. KRAJEI

AFTAC
PATRICK AFB, FL 32925
01CY ATTN TF/MAJ WILEY
01CY ATTN TN

AIR FORCE AVIONICS LABORATORY
WRIGHT-PATTERSON AFB, OH 45433
01CY ATTN AAD WADE HUNT
01CY ATTN AAD ALLEN JOHNSON

DEPUTY CHIEF OF STAFF
RESEARCH, DEVELOPMENT, & ACQ
DEPARTMENT OF THE AIR FORCE
WASHINGTON, D.C. 20330
01CY ATTN AFRDQ

HEADQUARTERS
ELECTRONIC SYSTEMS DIVISION/XR
DEPARTMENT OF THE AIR FORCE
HANSCOM AFB, MA 01731
01CY ATTN XR J. DEAS

HEADQUARTERS
ELECTRONIC SYSTEMS DIVISION/YSEA
DEPARTMENT OF THE AIR FORCE
HANSCOM AFB, MA 01732
01CY ATTN YSEA

HEADQUARTERS
ELECTRONIC SYSTEMS DIVISION/DC
DEPARTMENT OF THE AIR FORCE
HANSCOM AFB, MA 01731
01CY ATTN DCKC MAJ J.C. CLARK

COMMANDER
FOREIGN TECHNOLOGY DIVISION, AFSC
WRIGHT-PATTERSON AFB, OH 45433
O1CY ATTN NICD LIBRARY
O1CY ATTN ETD P. BALLARD

COMMANDER
ROME AIR DEVELOPMENT CENTER, AFSC
GRIFFISS AFB, NY 13441
O1CY ATTN DOC LIBRARY/TSLD
O1CY ATTN OCSE V. COYNE

SAMSO/SZ
POST OFFICE BOX 92960
WORLDWAY POSTAL CENTER
LOS ANGELES, CA 90009
(SPACE DEFENSE SYSTEMS)
O1CY ATTN SZJ

STRATEGIC AIR COMMLND/XPFS
OFFUTT AFB, NB 68113
O1CY ATTN XPFS MAJ B. STEPHAN
O1CY ATTN ADWATE MAJ BRUCE BAUER
O1CY ATTN NRT
O1CY ATTN DOK CHIEF SCIENTIST

SAMSO/SK
P.O. BOX 92960
WORLDWAY POSTAL CENTER
LOS ANGELES, CA 90009
O1CY ATTN SKA (SPACE COMM SYSTEMS)
M. CLAVIN

SAMSO/MN
NORTON AFB, CA 92409
(MINUTEMAN)
O1CY ATTN MNWL LTC KENNEDY

COMMANDER
ROME AIR DEVELOPMENT CENTER, AFSC
HANSCOM AFB, MA 01731
O1CY ATTN EEP A. LORENTZEN

DEPARTMENT OF ENERGY
LIBRARY ROOM G-042
WASHINGTON, D.C. 20545
O1CY ATTN DOC CON FOR A. LABOWITZ

DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
P.O. BOX 5400
ALBUQUERQUE, NM 87115
O1CY ATTN DOC CON FOR D. SHERWOOD

EG&G, INC.
LOS ALAMOS DIVISION
P.O. BOX 809
LOS ALAMOS, NM 85544
O1CY ATTN DOC CON FOR J. BREEDLOVE

UNIVERSITY OF CALIFORNIA
LAWRENCE LIVERMORE LABORATORY
P.O. BOX 808
LIVERMORE, CA 94550
O1CY ATTN DOC CON FOR TECH INFO DEPT
O1CY ATTN DOC CON FOR L-389 R. OTT
O1CY ATTN DOC CON FOR L-31 R. HAGER
O1CY ATTN DOC CON FOR L-46 F. STWARD

LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1663
LOS ALAMOS, NM 87545
O1CY ATTN DOC CON FOR J. WOLCOTT
O1CY ATTN DOC CON FOR R.F. TASCHEK
O1CY ATTN DOC CON FOR E. JONES
O1CY ATTN DOC CON FOR J. MALIK
O1CY ATTN DOC CON FOR R. JEFFRIES
O1CY ATTN DOC CON FOR J. ZINN
O1CY ATTN DOC CON FOR P. KEATON
O1CY ATTN DOC CON FOR D. WESTERVELT

SANDIA LABORATORIES
P.O. BOX 5800
ALBUQUERQUE, NM 87115
O1CY ATTN DOC CON FOR W. BROWN
O1CY ATTN DOC CON FOR A. THORNBROUGH
O1CY ATTN DOC CON FOR T. WRIGHT
O1CY ATTN DOC CON FOR D. DAHLGREN
O1CY ATTN DOC CON FOR 3141
O1CY ATTN DOC CON FOR SPACE PROJECT DIV

SANDIA LABORATORIES
LIVERMORE LABORATORY
P.O. BOX 969
LIVERMORE, CA 94550
O1CY ATTN DOC CON FOR B. MURPHEY
O1CY ATTN DOC CON FOR T. COOK

OFFICE OF MILITARY APPLICATION
DEPARTMENT OF ENERGY
WASHINGTON, D.C. 20545
O1CY ATTN DOC CON DR. YO SONG

OTHER GOVERNMENT

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234
(ALL CORRES: ATTN SEC OFFICER FOR)
O1CY ATTN R. MOORE

INSTITUTE FOR TELECOM SCIENCES
NATIONAL TELECOMMUNICATIONS & INFO ADMIN
BOULDER, CO 80303

O1CY ATTN A. JEAN (UNCLASS ONLY)
O1CY ATTN W. UTLAUT
O1CY ATTN D. CROMBIE
O1CY ATTN L. BERRY

NATIONAL OCEANIC & ATMOSPHERIC ADMIN
ENVIRONMENTAL RESEARCH LABORATORIES
DEPARTMENT OF COMMERCE
BOULDER, CO 80302

O1CY ATTN R. GRUBB
O1CY ATTN AERONOMY LAB G. REID

DEPARTMENT OF DEFENSE CONTRACTORS

AEROSPACE CORPORATION

P.O. BOX 92957

LOS ANGELES, CA 90009

O1CY ATTN I. GARFUNKEL
O1CY ATTN T. SALMI
O1CY ATTN V. JOSEPHSON
O1CY ATTN S. BOWER
O1CY ATTN N. STOCKWELL
O1CY ATTN D. OLSEN

ANALYTICAL SYSTEMS ENGINEERING CORP

5 OLD CONCORD ROAD

BURLINGTON, MA 01803

O1CY ATTN RADIO SCIENCES

BERKELEY RESEARCH ASSOCIATES, INC.

P.O. BOX 983

BERKELEY, CA 94701

O1CY ATTN J. WORKMAN
O1CY ATTN C. PRETTIE

BOEING COMPANY, THE

P.O. BOX 3707

SEATTLE, WA 98124

O1CY ATTN G. KEISTER
O1CY ATTN D. MURRAY
O1CY ATTN G. HALL
O1CY ATTN J. KENNEY

BROWN ENGINEERING COMPANY, INC.

CUMMINGS RESEARCH PARK

HUNTSVILLE, AL 35807

O1CY ATTN ROMEO A. DELIBERIS

CALIFORNIA AT SAN DIEGO, UNIV OF

P.O. BOX 6049

SAN DIEGO, CA 92106

CHARLES STARK DRAPER LABORATORY, INC.

555 TECHNOLOGY SQUARE

CAMBRIDGE, MA 02139

O1CY ATTN D.B. COX

O1CY ATTN J.P. GILMORE

COMSAT LABORATORIES

LINTHICUM ROAD

CLARKSBURG, MD 20734

O1CY ATTN G. HYDE

CORNELL UNIVERSITY

DEPARTMENT OF ELECTRICAL ENGINEERING

ITHACA, NY 14850

O1CY ATTN D.T. FARLEY, JR.

ELECTROSPACE SYSTEMS, INC.

BOX 1359

RICHARDSON, TX 75080

O1CY ATTN H. LOGSTON

O1CY ATTN SECURITY (PAUL PHILLIPS)

ESL, INC.

495 JAVA DRIVE

SUNNYVALE, CA 94086

O1CY ATTN J. ROBERTS

O1CY ATTN JAMES MARSHALL

GENERAL ELECTRIC COMPANY

SPACE DIVISION

VALLEY FORGE SPACE CENTER

GODDARD BLVD KING OF PRUSSIA

P.O. BOX 8555

PHILADELPHIA, PA 19101

O1CY ATTN M.H. BORTNER SPACE SCI LAB

GENERAL ELECTRIC COMPANY

P.O. BOX 1122

SYRACUSE, NY 13201

O1CY ATTN F. REIBERT

GENERAL ELECTRIC TECH SERVICES CO., INC.

HMES

COURT STREET

SYRACUSE, NY 13201

O1CY ATTN G. MILLMAN

GENERAL RESEARCH CORPORATION

SANTA BARBARA DIVISION

P.O. BOX 6770

SANTA BARBARA, CA 93111

O1CY ATTN JOHN ISE, JR.

O1CY ATTN JOEL GARBARINO

GEOPHYSICAL INSTITUTE
UNIVERSITY OF ALASKA
FAIRBANKS, AK 99701
(ALL CLASS ATTN: SECURITY OFFICER)
01CY ATTN T.N. DAVIS (UNCLASS ONLY)
01CY ATTN TECHNICAL LIBRARY
01CY ATTN NEAL BROWN (UNCLASS ONLY)

GTE SYLVANIA, INC.
ELECTRONICS SYSTEMS GRP-EASTERN DIV
77 A STREET
NEEDHAM, MA 02194
01CY ATTN MARSHALL CROSS

HSS, INC.
2 ALFRED CIRCLE
BEDFORD, MA 01730
01CY ATTN DONALD HANSEN

ILLINOIS, UNIVERSITY OF
107 COBLE HALL
150 DAVENPORT HOUSE
CHAMPAIGN, IL 61820
(ALL CORRES ATTN DAN MCCLELLAND)
01CY ATTN K. YEH

INSTITUTE FOR DEFENSE ANALYSES
400 ARMY-NAVY DRIVE
ARLINGTON, VA 22202
01CY ATTN J.M. AEIN
01CY ATTN ERNEST BAUER
01CY ATTN HANS WOLFARD
01CY ATTN JOEL BENGSTON

INTL TEL & TELEGRAPH CORPORATION
500 WASHINGTON AVENUE
NUTLEY, NJ 07110
01CY ATTN TECHNICAL LIBRARY

JAYCOR
11011 TORREYANA ROAD
P.O. BOX 85154
SAN DIEGO, CA 92138
01CY ATTN J.L. SPERLING

JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
JOHNS HOPKINS ROAD
LAUREL, MD 20810
01CY ATTN DOCUMENT LIBRARIAN
01CY ATTN THOMAS POTEMRA
01CY ATTN JOHN DASSOULAS

KAMAN SCIENCES CORP
P.O. BOX 7463
COLORADO SPRINGS, CO 80933

01CY ATTN T. MEAGHER
KAMAN TEMPO-CENTER FOR ADVANCED STUDIES
816 STATE STREET (P.O. DRAWER QQ)
SANTA BARBARA, CA 93102
01CY ATTN DASIAC
01CY ATTN TIM STEPHANS
01CY ATTN WARREN S. KNAPP
01CY ATTN WILLIAM MCNAMARA
01CY ATTN B. GAMBILL

LINKABIT CORP
10453 ROSELLE
SAN DIEGO, CA 92121
01CY ATTN IRWIN JACOBS

LOCKHEED MISSILES & SPACE CO., INC
P.O. BOX 504
SUNNYVALE, CA 94088
01CY ATTN DEPT 60-12
01CY ATTN D.R. CHURCHILL

LOCKHEED MISSILES & SPACE CO., INC.
3251 HANOVER STREET
PALO ALTO, CA 94304
01CY ATTN MARTIN WALT DEPT 52-12
01CY ATTN W.L. IMHOF DEPT 52-12
01CY ATTN RICHARD G. JOHNSON DEPT 52-12
01CY ATTN J.B. CLADIS DEPT 52-12

LOCKHEED MISSILE & SPACE CO., INC.
HUNTSVILLE RESEARCH & ENGR. CTR.
4800 BRADFORD DRIVE
HUNTSVILLE, AL 35807
ATTN DALE H. DIVIS

MARTIN MARIETTA CORP
ORLANDO DIVISION
P.O. BOX 5837
ORLANDO, FL 32805
01CY ATTN R. HEFFNER

M.I.T. LINCOLN LABORATORY
P.O. BOX 73
LEXINGTON, MA 02173
01CY ATTN DAVID M. TOWLE
01CY ATTN P. WALDRON
01CY ATTN L. LOUGHLIN
01CY ATTN D. CLARK

MCDONNELL DOUGLAS CORPORATION
5301 BOLSA AVENUE
HUNTINGTON BEACH, CA 92647
01CY ATTN N. HARRIS
01CY ATTN J. MOULE
01CY ATTN GEORGE MROZ
01CY ATTN W. OLSON
01CY ATTN R.W. HALPRIN

01CY ATTN TECHNICAL LIBRARY SERVICES
MISSION RESEARCH CORPORATION
735 STATE STREET
SANTA BARBARA, CA 93101
01CY ATTN P. FISCHER
01CY ATTN W.F. CREVIER
01CY ATTN STEVEN L. GUTSCHE
01CY ATTN D. SAPPENFIELD
01CY ATTN R. BOGUSCH
01CY ATTN R. HENDRICK
01CY ATTN RALPH KILB
01CY ATTN DAVE SOWLE
01CY ATTN F. FAJEN
01CY ATTN M. SCHEIBE
01CY ATTN CONRAD L. LONGMIRE
01CY ATTN WARREN A. SCHLUETER

MITRE CORPORATION, THE
P.O. BOX 208
BEDFORD, MA 01730
01CY ATTN JOHN MORGANSTERN
01CY ATTN G. HARDING
01CY ATTN C.E. CALLAHAN

MITRE CORP
WESTGATE RESEARCH PARK
1820 DOLLY MADISON BLVD
MCLEAN, VA 22101
01CY ATTN W. HALL
01CY ATTN W. FOSTER

PACIFIC-SIERRA RESEARCH CORP
1456 CLOVERFIELD BLVD.
SANTA MONICA, CA 90404
01CY ATTN E.C. FIELD, JR.

PENNSYLVANIA STATE UNIVERSITY
IONOSPHERE RESEARCH LAB
318 ELECTRICAL ENGINEERING EAST
UNIVERSITY PARK, PA 16802
(NO CLASS TO THIS ADDRESS)
01CY ATTN IONOSPHERIC RESEARCH LAB

PHOTOMETRICS, INC.
442 MARRETT ROAD
LEXINGTON, MA 02173
01CY ATTN IRVING L. KOFSKY

PHYSICAL DYNAMICS, INC.
P.O. BOX 3027
BELLEVUE, WA 98009
01CY ATTN E.J. FREMOUN

PHYSICAL DYNAMICS, INC.
P.O. BOX 10367
OAKLAND, CA 94610
ATTN A. THOMSON

R & D ASSOCIATES
P.O. BOX 9695
MARINA DEL REY, CA 90291
01CY ATTN FORREST GILMORE
01CY ATTN BRYAN GABBEARD
01CY ATTN WILLIAM B. WRIGHT, JR.
01CY ATTN ROBERT F. LELEVIER
01CY ATTN WILLIAM J. KARZAS
01CY ATTN H. ORY
01CY ATTN C. MACDONALD
01CY ATTN R. TURCO

RAND CORPORATION, THE
1700 MAIN STREET
SANTA MONICA, CA 90406
01CY ATTN CULLEN CRAIN
01CY ATTN ED BEDROZIAN

RAYTHEON CO.
528 BOSTON POST ROAD
SUDBURY MA 01776
01CY ATTN BARBARA ADAMS

RIVERSIDE RESEARCH INSTITUTE
80 WEST END AVENUE
NEW YORK, NY 10023
01CY ATTN VINCE TRAPANI

SCIENCE APPLICATIONS, INC.
P.O. BOX 2351
LA JOLLA, CA 92038
01CY ATTN LEWIS M. LINSON
01CY ATTN DANIEL A. HAMLIN
01CY ATTN E. FRIEMAN
01CY ATTN E.A. STRAKER
01CY ATTN CURTIS A. SMITH
01CY ATTN JACK MCDUGALL

SCIENCE APPLICATIONS, INC
1710 GOODRIDGE DR.
MCLEAN, VA 22102
ATTN: J. COCKAYNE

SRI INTERNATIONAL

333 RAVENSWOOD AVENUE
MENLO PARK, CA 94025

OICV ATTN DONALD NEILSON
OICV ATTN ALAN BURNS
OICV ATTN G. SMITH
OICV ATTN L.L. COSE
OICV ATTN DAVID A. JOHNSON
OICV ATTN WALTER G. CHESNUT
OICV ATTN CHARLES L. RINO
OICV ATTN WALTER JAYE
OICV ATTN M. BARON
OICV ATTN RAY L. LEADABRAND
OICV ATTN G. CARPENTER
OICV ATTN G. PRICE
OICV ATTN J. PETERSON
OICV ATTN R. HAKE, JR.
OICV ATTN V. GONZALES
OICV ATTN D. MCDANIEL

STEWART RADIANCE LABORATORY

UTAH STATE UNIVERSITY
1 DE ANGELO DRIVE
BEDFORD, MA 01730

OICV ATTN J. ULWICK

TECHNOLOGY INTERNATIONAL CORP

75 WIGGINS AVENUE
BEDFORD, MA 01730

OICV ATTN W.P. BOQUIST

TRW DEFENSE & SPACE SYS GROUP

ONE SPACE PARK

REDONDO BEACH, CA 90278

OICV ATTN R. K. PLEBUCH
OICV ATTN S. ALTSCHULER
OICV ATTN D. DEE

VISIDYNE

SOUTH BEDFORD STREET
BURLINGTON, MASS 01803

OICV ATTN W. REIDY
OICV ATTN J. CARPENTER
OICV ATTN C. HUMPHREY

IONOSPHERIC MODELING DISTRIBUTION LIST
(UNCLASSIFIED ONLY)

PLEASE DISTRIBUTE ONE COPY TO EACH OF THE FOLLOWING PEOPLE:

NAVAL RESEARCH LABORATORY
WASHINGTON, D.C. 20375
DR. P. MANGE - CODE 4101
DR. R. MEIER - CODE 4141
DR. E. SZUSZCZEWICZ - CODE 4187
DR. J. GOODMAN - CODE 4180
DR. R. RODRIGUEZ - CODE 4187

A.F. GEOPHYSICS LABORATORY
L.G. HANSCOM FIELD
BEDFORD, MA 01730
DR. T. ELKINS
DR. W. SWIDER
MRS. R. SAGALYN
DR. J.M. FORBES
DR. T.J. KENESHEA
DR. J. AARONS
DR. H. CARLSON
DR. J. JASPERSE

CORNELL UNIVERSITY
ITHACA, NY 14850
DR. W.E. SWARTZ
DR. R. SUDAN
DR. D. FARLEY
DR. M. KELLEY

HARVARD UNIVERSITY
HARVARD SQUARE
CAMBRIDGE, MA 02138
DR. M.B. McELROY
DR. R. LINDZEN

INSTITUTE FOR DEFENSE ANALYSIS
400 ARMY/NAVY DRIVE
ARLINGTON, VA 22202
DR. E. BAUER

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PLASMA FUSION CENTER
LIBRARY, NW16-262
CAMBRIDGE, MA 02139

NASA
GODDARD SPACE FLIGHT CENTER
GREENBELT, MD 20771
DR. S. CHANDRA
DR. K. MAEDA
DR. R.F. BENSON
NATIONAL TECHNICAL INFORMATION CENTER
CAMERON STATION
ALEXANDRIA, VA 22314
12CY ATTN TC

COMMANDER
NAVAL AIR SYSTEMS COMMAND
DEPARTMENT OF THE NAVY
WASHINGTON, D.C. 20360
DR. T. CZUBA

COMMANDER
NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CA 92152
MR. R. ROSE - CODE 5321

NOAA
DIRECTOR OF SPACE AND ENVIRONMENTAL
LABORATORY
BOULDER, CO 80302
DR. A. GLENN JEAN
DR. G.W. ADAMS
DR. D.N. ANDERSON
DR. K. DAVIES
DR. R. F. DONNELLY

OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217
DR. G. JOINER

PENNSYLVANIA STATE UNIVERSITY
UNIVERSITY PARK, PA 16802
DR. J.S. NISBET
DR. P.R. ROHRBAUGH
DR. L.A. CARPENTER
DR. M. LEE
DR. R. DIVANY
DR. P. BENNETT
DR. F. KLEVANS

PRINCETON UNIVERSITY
PLASMA PHYSICS LABORATORY
PRINCETON, NJ 08540
DR. F. PERKINS

SCIENCE APPLICATIONS, INC.
1150 PROSPECT PLAZA
LA JOLLA, CA 92037
DR. D.A. HAMLIN
DR. L. LINSON
DR. E. FRIEMAN

STANFORD UNIVERSITY
STANFORD, CA 94305
DR. P.M. BANKS

U.S. ARMY ABERDEEN RESEARCH
AND DEVELOPMENT CENTER
BALLISTIC RESEARCH LABORATORY
ABERDEEN, MD
DR. J. HEIMERL

UNIVERSITY OF CALIFORNIA,
BERKELEY
BERKELEY, CA 94720
DR. M. HUDSON

UNIVERSITY OF CALIFORNIA
LOS ALAMOS SCIENTIFIC LABORATORY
J-10, MS-664
LOS ALAMOS, NM 87545
M. PONGRATZ
D. SIMONS
G. BARASCH
L. DUNCAN
P. BERNHARDT

UNIVERSITY OF CALIFORNIA,
LOS ANGELES
405 HILLGARD AVENUE
LOS ANGELES, CA 90024
DR. F.V. CORONITI
DR. C. KENNEL
DR. A.Y. WONG

UNIVERSITY OF MARYLAND
COLLEGE PARK, MD 20740
DR. K. PAPADOPOULOS
DR. E. OTT

UNIVERSITY OF PITTSBURGH
PITTSBURGH, PA 15213
DR. N. ZABUSKY
DR. M. BIONDI
DR. E. OVERMAN

UTAH STATE UNIVERSITY
4TH AND 8TH STREETS
LOGAN, UTAH 84322
DR. R. HARRIS
DR. K. BAKER
DR. R. SCHUNK

DATE
ILMEI
— 8